Heliyon 8 (2022) e09169

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Analysis of the socio-economic and environmental impacts of construction waste and management practices

Shitaw Tafesse *, Yidnekachew Esayas Girma, Eliyas Dessalegn

Department of Construction Technology and Management, College of Engineering and Technology, Dilla University, Dilla, Ethiopia

ARTICLE INFO

Keywords:
Construction waste
Environment
Impact of waste
Sustainability
Waste management

ABSTRACT

This study aims to analyze the significant socioeconomic and environmental impacts of construction waste and to indicate management strategies. An extensive review of the literature and interviews with construction experts were used to identify waste impact factors. Then a questionnaire survey was conducted based on a five-point Likert scale and the data were analyzed by descriptive statistics. The result showed that construction waste becomes a challenge for almost 95.71% of ongoing construction projects. However, only 57.14% of the construction companies have recorded and measured the volume of material waste. From purchased materials, 6–10% is recorded as waste that lead to project cost overrun. In addition, there is no professional assigned to handle waste issues in 75.71% of construction companies. The study also indicates that project cost overrun, pollution of the environment, reduction in profit and failure of construction firms, excessive consumption of raw materials, and public health and safety risks are ranked as the five major impacts of construction waste, respectively. Employing a waste management officer, using prefabricated or off-site components, implementing strong onsite management practices, reusing and recycling materials leftover on the sites, and practicing green building codes and specifications are measures devised to mitigate construction waste and its impacts.

1. Introduction

The economic development of any country is largely dependent on construction projects (Husnain et al., 2017). The construction industry provides numerous job opportunities, economic contributions, and serves as a basis for other businesses (Ofori, 2015; Venugopal et al., 2020). The role it plays in socioeconomic development goes beyond its share in national output (Lopes et al., 2011; Akadiri et al., 2012; Tafesse, 2020). It includes building, civil, and other heavy engineering projects that are responsible for the growth of every country (Papargyropoulou et al., 2011; Oladipo and Oni, 2012). In developing countries, construction activities account for 80% of the total capital asset, 10 % of their GDP, and more than 50 % of the wealth invested in fixed assets (Jekale, 2004).

At the same time, the built environment consumes a significant volume of natural resources and accounts for the majority of solid waste generations (Merino et al., 2010; Hakan et al., 2012; da Paz, 2018; Muhammad et al., 2020). There is an increase in the amount of construction waste generated from construction sites due to a variety of reasons (Banias et al., 2011; Ignacio et al., 2011; Ajayi et al., 2017). Compared to other types of waste, construction waste has a high volume (Luangcharoenrat et al., 2019; Tafesse and Adugna, 2021), representing one third of all waste (Gottsche and Kelly, 2018). As indicated in a recent study, construction waste constitutes approximately 10–30% of waste disposed of at landfill sites around the world (Polat et al., 2017). The quantity of natural resources consumed and waste generated by construction sites is also estimated by (Ignacio et al., 2011). Their study has shown that civil works and building construction consume 60% of raw materials, with building projects accounting for 40% of this volume. In addition, the construction industry produces approximately 35% of total waste to the environment globally (Solís-Guzmán et al., 2009; Yuan et al., 2012). Similarly, the industry uses 35% of energy and releases 40% of carbon dioxide into the atmosphere (Luangcharoenrat et al., 2019), at the global level, the construction industry is responsible for 40% of total energy and natural resource consumption (Asif et al., 2007).

To this end, construction waste received attention from industry practitioners and researchers (Tam, 2008; Lu and Yuan, 2011; Adewuyi and Odesola, 2016), currently, there has been an increase in global awareness of construction waste (Shant and Daphene, 2014; Bajjou and Chafi, 2019; Tafesse, 2021). For example, Eze et al. (2016) studied and

* Corresponding author.
E-mail addresses: shitu.taf@gmail.com, shitu.taf@du.edu.et (S. Tafesse).

https://doi.org/10.1016/j.heliyon.2022.e09169
Received 1 December 2021; Received in revised form 8 February 2022; Accepted 18 March 2022

noted that waste damages the construction project, the environment, and the economy. As presented by other studies, energy efficiency, environment, and sustainability are mainly influenced by construction waste (Castellano et al., 2016; Ghaleb et al., 2021). In addition, urban sustainability, economic values, environmental safety, and community well-being are the main areas impacted by construction wastes (Eze et al., 2016; Laborel-Préneron et al., 2016; Aslam et al., 2020). In this regard, it can be said that the environment, society, and economy are the three pillar areas influenced by construction waste (Olanrewaju and Ogunmakinde, 2020; Rodríguez et al., 2020).

In particular, health risks caused by a variety of diseases, traffic congestion, conflicts with construction firms, closing drainage, and leading to floods and waste transported by rainwater are some of the main social impacts of construction waste (Nguimalet, 2007; ELARD and GAA, 2009; Aboginije et al., 2020). In addition, as a by-product of construction work, waste creates negative environmental impacts (Wu et al., 2016), which includes soil contamination, water contamination, energy and natural resources consumption, environmental degradation, and landscape deterioration (Oladipo and Oni, 2012; Edwards, 2014; Mydin et al., 2014; Milad and Sungjin, 2020). Moreover, material waste also has a negative economic impact by contributing additional costs to projects (Olusanjo et al., 2014). For instance, the contribution of construction waste to the total project cost overrun is 30% of the total cost of materials (Eze et al., 2016; Olusanjo et al., 2014), approximately 10–15% of purchased materials for the construction of a project is recorded as a waste (Wong and Yip, 2004). In this regard, construction waste has been argued to be one of the main causes of economic reduction and business failure in the construction sectors (Enshassi et al., 2006; Yeheyis et al., 2013).

In general, construction waste has harmful impacts not only in developing countries but also in developed nations (Kabirifar et al., 2021), findings from previous work have shown that construction projects in low and middle-income countries, still face construction waste (Wu et al., 2016; Ghaleb et al., 2021). Construction waste does not only affect the construction industry alone but touches the whole economy of the concerned countries (Jawad and Omar, 2016). In recent years construction waste has been recognized as the main obstacle to sustainability (Al-Hajj and Hamani, 2011; Anderson and Thornback, 2012), while sustainability has become a focus topic by different organizations (Narcis et al., 2019). Globally, construction waste has been a topic of research that many researchers have focused on (Enshassi et al., 2006; Akadiri et al., 2012; Adewuyi and Odesola, 2016; Bajjou and Chafi, 2019; Aboginije et al., 2020), and low-and middle-income countries lag in research related to waste problems and, particularly in Ethiopia, Addis Ababa, none of these studies have been focused on the impacts of construction waste except (Asmara, 2015; Endale, 2017; Tafesse, 2021), which are concentrated on waste management strategies and (Tafesse and Adugna, 2021), focused on the critical factors causing construction waste. However, the relevance of studies conducted abroad is not tested and is unknown to Ethiopian construction sectors, which require detailed investigations. Therefore, this research aims to analyze the overall impacts of construction waste and to indicate management strategies. To achieve this aim, the study follows the following specific objectives;

1. To determine the contribution of construction waste to the project cost overrun
2. To identify the major economic, social, and environmental impacts of construction waste
3. To indicate measures that could be taken for preventing and reducing waste generated by construction activities and their impacts.

1.1. Significance of the study

The implications of the study findings are significant, focusing on social, practical, policy, and research values. The study broadens knowledge of construction waste, resulting in a better understanding of impacts posed by waste on social, economic, and environment that can provide idea of measures to put in place to insure gradual to full control of waste in building projects. In this regard, the output of the study can be used as a guide for construction stakeholders, policymakers, and other government agencies in Addis Ababa, Ethiopia, and other developing countries. This, in turn, will improve the sustainability of the construction sectors by maintaining a cleaner environment, increasing the economic benefit of construction stakeholders, and reducing the social impacts caused by construction waste.

1.2. Limitation of the study

The geographical scope of the research was limited to Addis Ababa and the study was also mainly restricted to building construction projects. In addition, the output of the study depends on the feedback obtained from seventy (70) respondents using structured questionnaires. However, the study fills a knowledge gap on the impact of construction waste and introduces a systematic and comprehensive finding that can be used by the construction stakeholders and government organizations as a benchmark, particularly in developing countries. Furthermore, future

Figure 1. Waste of construction materials (authors field observation).

researchers who want to further investigate areas related to this study in other parts of Ethiopia or other developing countries can validate their findings using the result of this study.

2. Research method

The research was focused on the impacts of construction waste and management strategies. Building construction projects in Addis Ababa, Ethiopia, were used for the study. The number of construction projects and other buildings increases from time to time in the place. At the same time, a large quantity of waste is generated from both public and private ongoing building projects. For example, construction materials such as cement, hollow concrete block, reinforcement bars, concrete, and mortars are highly wasted (Figure 1).

2.1. Data collection

At the beginning, a detailed literature review was conducted to identify the impacts of construction waste. The review included articles that discuss the impacts faced by construction waste. After a detailed review of the literature, twenty relevant factors of the impacts of construction waste were identified. The factors identified from the literature can be the input for producing the questionnaire to determine whether these factors are relevant to the local environment (Bajjou and Chafi, 2019). In this study, the whole factors identified from the literature were considered as input to develop the questionnaire.

Then, before producing the final version of the questionnaire, a pilot survey was conducted to ensure the relevance of the questionnaire and to examine the adequacy of the identified factors with the context of the Addis Ababa building construction sectors. While carrying out data collection, an in-depth interview with individual or multiple participants could be employed (Creswell, 2013). A pilot survey can be conducted to ensure the research instrument meets a suitable level of quality in terms of credibility and dependability (Fashina et al., 2020, 2021). The method was used to explore real information from participants on construction waste in addition to a review of previous studies (Tafesse and Adugna, 2021).

The interviewees included ten experts in the field of construction project management; three project managers, four site managers, two office engineers, and one design and supervision manager. With those experts; the length of the questionnaire, level of complexity, structure of the questions, the relevance of the identified factor from the literature review were verified. During this stage, five new impacts factors of construction waste (spending costs to landfill fee for disposing of wastes, transportation charges to transport wastes, increase price of raw materials, disagreement between construction stakeholders, and losing reputability and caused conflicts with the community) were added to the questionnaire. Table 1 illustrates twenty (20) impacts of construction waste extracted from literature and five (5) factors added during the pilot survey or interviews.

Table 1. Impact factors of construction waste.

No.	Impacts of construction wastes	Reference/Source
1	Project cost overrun	Wong and Yip (2004), Eze et al. (2016), and Olusanjo et al., 2014
2	Disease-associated with high levels of air pollutants	Nguimalet (2007)
3	Pollution of the environment by discharging chemicals and other materials	Coelho and Brito (2012), Hossain and Ng (2019) and Luangcharoenrat et al. (2019)
4	Reduction in profit and failure of construction firms	Enshassi et al. (2006), Wahab and Lawal, 2011, and Dajadian and Koch (2014)
5	Lower the GDP contribution of construction firms	Enshassi et al. (2006) and Jawad and Omar, 2016
6	Excessive consumption of raw material and resources depletion	Asif et al. (2007) and Ignacio et al. (2011)
7	Public health and safety risks	Nguimalet (2007) and Tafesse (2021)
8	Pollution of soil by chemicals and other materials	Oladipo and Oni (2012), Edwards (2014), and Mydin et al. (2014)
9	Delay of project time or time overrun	Memon et al. (2020) and Tafesse and Adugna (2021)
10	Sustainability reduction of construction sectors	Castellano et al. (2016) and Ghaleb et al. (2021)
11	Land occupancy or land consumption for dumping wastes	Yeheyis et al. (2013) and Polat et al. (2017)
12	Traffic congestion	ELARD and GAA (2009)
13	Generate waste that causes water pollution	Olusanjo et al., 2014 and Aboginije et al. (2020)
14	Effect on biodiversity and destruction of the living environment	ELARD and GAA (2009)
15	Severe effects on the welfare of the waste disposed of communities	Eze et al. (2016), Laborel-Préneron et al. (2016), and Aslam et al. (2020)
16	Emission of greenhouse gases into the atmosphere causes climate change	Baek et al. (2013) and Ajayi et al. (2015)
17	Dust generation to the surrounding	Solís-Guzmán et al. (2009) and Yuan et al. (2012)
18	Flooding due to blockages by waste debris	Nguimalet (2007) and ELARD and GAA (2009)
19	Increase in illegal dumping	Tafesse (2021)
20	Reduce agricultural productivity	Josimovic et al. (2014) and Olusanjo et al., 2014
21	Spending costs to landfill fee for disposing of wastes	Interview/pilot survey
22	Transportation charges to transport wastes	Interview/pilot survey
23	Increase price of raw materials	Interview/pilot survey
24	Disagreement between construction stakeholders	Interview/pilot survey
25	Losing reputability and caused conflicts with the community	Interview/pilot survey

2.2. Questionnaire design

The identified impact factors were then combined and designed in a questionnaire. Finally, the modified version of the questionnaire was sent to eighty-five participants in Addis Ababa public and private building construction projects, such as clients, consultants, and contractors using purposive sampling techniques. The respondents were first asked to provide background information about their profession, organization, years of experience, the existence of construction wastes, and its contribution to project cost overrun and then asked to rate the socio-economic and environmental impact of construction waste on a 5-point Likert scale. Figure 2 illustrates the methodological approaches to the study.

2.3. Data analysis

The data collected from construction experts were analyzed using descriptive statistics methods in SPSS version 26. The mean score (MS) was estimated using the formula in Eq. (1).

$$MS = \frac{\sum_{i=1}^{5} W_i X_i}{\sum_{i=1}^{5} X_i}; 1 \leq MS \leq 5 \tag{1}$$

Where; MS is the mean score, W is the weight (score) assigned to each variable by the respondents that range from 1 to 5, with 1 representing very low impact, 2 = low impact, 3 = medium impact, 4 = high impact, and 5 = and very high impact, X is the level of rating (frequency of the index of the ith response) and i is the response category index (the serial numbering of the respondents). The mean ranking of

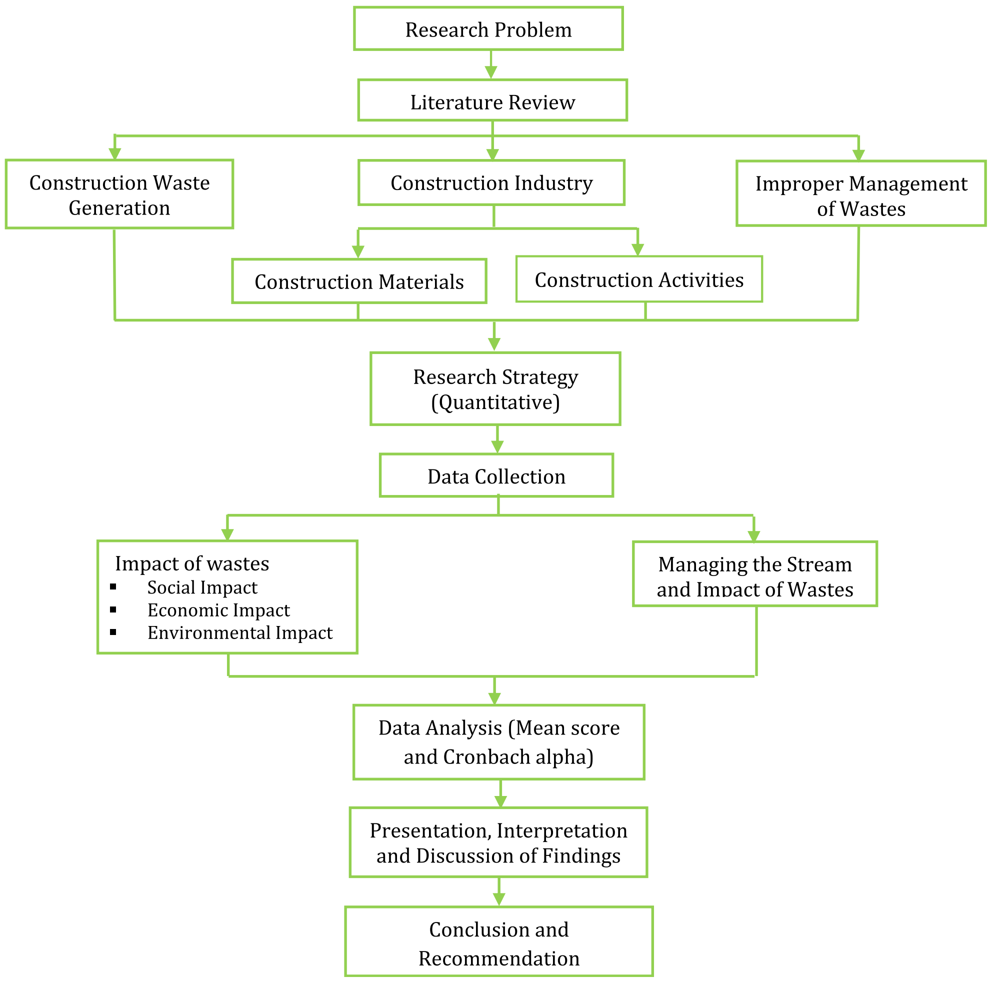


Figure 2. Flow chart of the research.

each item is presented to provide a clearer picture of the level of agreement reached by the study respondents and to identify the main findings of the study.

2.3.1. Reliability analysis

Reliability testing is one of the first essential steps to be considered in statistical analysis (Enshassi et al., 2010; Ye et al., 2014). Cronbach's alpha was used to evaluate the reliability or internal consistency of the measurement of the questionnaires using Eq. (2) (Cronbach, 1951).

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum \delta i^2}{\delta x}\right) \tag{2}$$

Where α, Cronbach alpha; K represents the number of items; δ_{i^2} represents the variance of the scores for each item; δ_x represents the scores for each element; $\sum \delta i^2$ represents the variance of the total variance of the observed test. Cronbach's alpha coefficient was used to determine the internal consistency of the questionnaire's criteria, as well as the suitability of the data for analysis, especially when using a Liker scale on a questionnaire (Nunnally and Bemstein, 2007; Feild, 2013). A Cronbach's alpha data, ranging from 0-1, were obtained to measure the internal consistency of the answers provided by the respondents (Nunnally and Bemstein, 2007; Fashina et al., 2021). Cronbach's alpha for this study is 0.956, indicating excellent reliability and internal consistency on the item of the research outputs. "Cronbach's alpha if item deleted" was checked to confirm the contribution of all items on the questionnaire to good internal consistency or reliability (Feild, 2013; Ajayi et al., 2017). In this case, any item with a Cronbach's alpha greater than the established value of 0.956 is not a good construct and should be removed from the list of variables. This implies that 95.60% of the answers provided by the participants on the social, economic, and environmental impacts of construction are reliable. As shown in Table 4, there is only one variable (increase in illegal dumping) with a value greater than 0.956, and it is thus excluded from further analysis. After removing this variable, the overall Cronbach's alpha coefficient is increased to 0.958.

2.3.2. Test of normality

A p-value below 0.05 in the normality test indicates that there is a significant difference between the groups of participants about the affected variable at 95% confidence level (Feild, 2013). Any p-value above 0.05 indicates that there is no significant difference among the groups (Ajayi et al., 2017). The results of the normality test for the data collected from study participants are shown in Table 4. The significant value of all items assessed is 0.000 for the Kolmogorov–Smirnov test, which is less than the required normality criterion of 0.05 ($p < 0.05$), and thus the participants' response to the impact of construction waste is not uniformly distributed.

2.4. Ethical clearance

Dilla University, College of Engineering and Technology *Research Ethics and Review Board (RERB) ad hoc committees* approved this research and it was carried out in accordance with the standard ethical practices required by academic research. Before distributing and filling out the study questionnaires, the participants of the study were verbally briefed

Table 2. Characteristics of the study respondents.

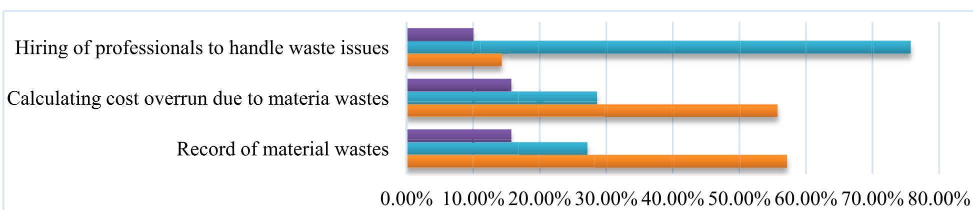
Characteristics of respondents	Frequency	Percentage (%)	Characteristics of respondents	Frequency	Percentage (%)
Company			***Position***		
Contractor	34	49	Site engineer	20	28.57
Consultant	24	34	Office engineer	16	22.86
Client	12	17	Project manager	7	10
Overall work experience			Quantity surveyor	7	10
1–5 year	19	27.14	Resident engineer	4	5.78
6–10 year	22	31.42	Site supervisor	4	5.78
11–15 year	18	25.72	General formal	3	4.29
≥16 year	11	15.72	Counterpart engineer	2	2.86
Work experience with their current position			Designer	2	2.86
1–5 year	31	44.29	Architect	2	2.86
6–10 year	30	42.86	Contract administer	2	2.86
11–15 year	5	7.14	Design and supervision department manager	1	1.43
≥16 year	4	5.71			

on the purpose of the research and a copy of letters requesting their genuine cooperation and consent to participate in the survey was submitted. It was also made clear to the respondents that their participation in the research survey was voluntary and that they had the option not to participate. In addition, the participants were assured that the information requested in the questionnaire would be kept confidential.

3. Results and discussion

3.1. Characteristics of the respondents

The characteristics of the respondents who provided information for the study were examined to determine the level of reliability of the data provided. Table 2 shows, of the 85 questionnaires sent out to respondents, 40 were to contractors, 30 to consultants, and 15 to clients based on their company type, and 70 (82.35%) were returned for the study; 34 (49%), 24 (34%), and 12 (17%) from contractors, consultants, and clients respectively. The findings also indicated that a large proportion (31.42%) of the 70 respondents surveyed had an average of 6–10 years of work experience in construction projects. Similarly, a breakdown of the assessed respondents revealed that 44.29% have been in their current position for 1–5 years. Based on their profession, site engineers and office engineers have a high proportion, accounting for 28.57% (20) and 22.86% (16) of all respondents, respectively. Additionally, project managers and quantity surveyors ranked third with 10% (7) of the total of respondents. The site supervisors and resident engineers make up 5.78% of the total (4). The general foreman had a 4.29% share (3). The architect, counterpart engineer, designer, and contract administrator



	Record of material wastes	Calculating cost overrun due to materia wastes	Hiring of professionals to handle waste issues
Not Sure	15.72%	15.72%	10%
No	27.14%	28.57%	75.72%
Yes	57.14%	55.71%	14.28%

Figure 3. The record of waste, its cost overrun, and waste management professionals.

Table 3. Level of the agreement of respondents on the existence of material waste.

Level of respondent responses	Contractors		Consultants		Clients		Overall	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Strongly agree	13	38.2	12	50	7	58.33	32	45.71
Agree	15	44.1	9	37.5	4	33.33	28	40
Moderately agree	4	11.8	2	8.33	1	8.33	7	10
Disagree	0	0	1	4.17	0	0	1	1.43
Strongly disagree	2	5.9	0	0	0	0	2	2.86
Total	34	100.0	24	100	12	100	70	100

represented 2.86% (2) of all respondents. The last position held by the respondent is design and supervision department manager, accounting for 1.43% (1) of the total number of respondents.

3.2. Assessing the existence of material waste

It is expected that every construction project should run within the estimated amount or quantity of construction materials. However, waste on any type of construction material has occurred in practice and has caused serious challenges in projects. This is because construction material constitutes a major cost component of construction projects (Musarat et al., 2020; Tafesse and Adugna, 2021), therefore, excessive usage of material resources has a direct impact on the overall project costs performances (Pheng and Hou, 2019). The amount of material waste generated by building construction projects causes serious social, economic, and environmental influences (Olanrewaju and Ogunmakinde, 2020; Rodríguez et al., 2020). Before determining the effects of waste, an assessment was performed to confirm its presence on building construction sites in Addis Ababa, Ethiopia. For this purpose, respondents were asked whether construction material waste is a problem or not in their project sites (Table 3).

Table 3 depicted; construction waste is a problem facing 95.71% ongoing construction projects with different level of agreement. As perceived by the respondents, only 1.43% of the construction companies indicated that construction waste is not a problem at their sites. The remaining 2.86% of total respondents strongly disagree with the issues or responses indicating that construction waste is not a problem in their organization. As a result, it is possible to conclude that construction waste is a challenge over 95.71% of building construction projects in Addis Ababa.

3.3. Measurement of the volume of waste

To enumerate the amount or extent of construction waste generated during construction works, material that is wasted or left on the site and sent to a landfill should typically be recorded. Figure 3 illustrates the construction companies' practice of recording waste, calculating the cost overrun of various materials waste, and the presence of professionals to handle construction material waste issues.

Figure 3 shows that 57.14% of the participants knew that their companies recorded the amount of construction waste generated from their sites, while the remaining 27.14% indicated that their companies did not record the amount of waste left at their sites. The other 15.72% of respondents were not sure whether their company had recorded construction material waste or not. At the same time, 55.71% of the construction companies calculate the costs overrun due to construction material waste. The remaining 28.57% of the survey respondents confirmed that they did not record or calculate the costs associated with construction waste, and the remaining 15.72% were not sure. Those who did not calculate the cost of material waste present a lack of strong management, a shortage of personnel, and a lack of daily data record practices as reasons. As perceived by 75.71% (53) of the respondents, no professional is assigned to handle waste issues in their organization. The other 14.28% of all the respondents employed a specific person to handle the issues, while the remaining 10% were not sure. However, those who did not hire a specific person (75.71%) indicates that quantity surveyors and site engineer had the required skills to manage construction material waste.

Furthermore, companies who responded 'Yes' for the calculation of the cost overrun of construction waste (55.71%) or 39 of 70 respondents (Figure 3), responded to the extent of the percentage of construction material waste compared to the total costs incurred to purchase construction materials (Figure 4).

According to the majority of research respondents (38.46%), from the total purchased material, 6–10% recorded as wastage. However, the general response of the respondents indicate that the cost overrun due to construction waste ranges from 1-25%, with an average contribution of 12.5%. As a result, the finding of this study indicates that construction waste is considered one of the major economic problems. From a previous study, the total cost overrun due to material waste is 30% of the purchased materials (Eze et al., 2016; Olusanjo et al., 2014). Depending on the material type, 8.47%–16.61% of the amount of material is recorded as waste out of the total materials delivered to construction sites (Adewuyi and Odesola, 2016). Similarly, a study by Shant and Daphene (2014) shows that at the end of every project, at least 20% of the purchased material will be unused. It is also further supported by other researchers, Adewuyi and Otali (2013), material wastage accounts for between 20-30% of project cost overruns. In other words, the reduction in construction waste can help to increase the total profit and gain economic stability for a country and construction firms (Husnain et al., 2017).

3.4. Impacts of construction waste

A thorough review of the existing literature and interviews were conducted to identify the existing impacts of construction waste. A total of 25 impacts of construction waste were identified and classified as economic, social, or environmental groups. As presented in Table 4, the impact items were subjected to quantitative data analysis using SPSS (descriptive, reliability analysis, and normality test).

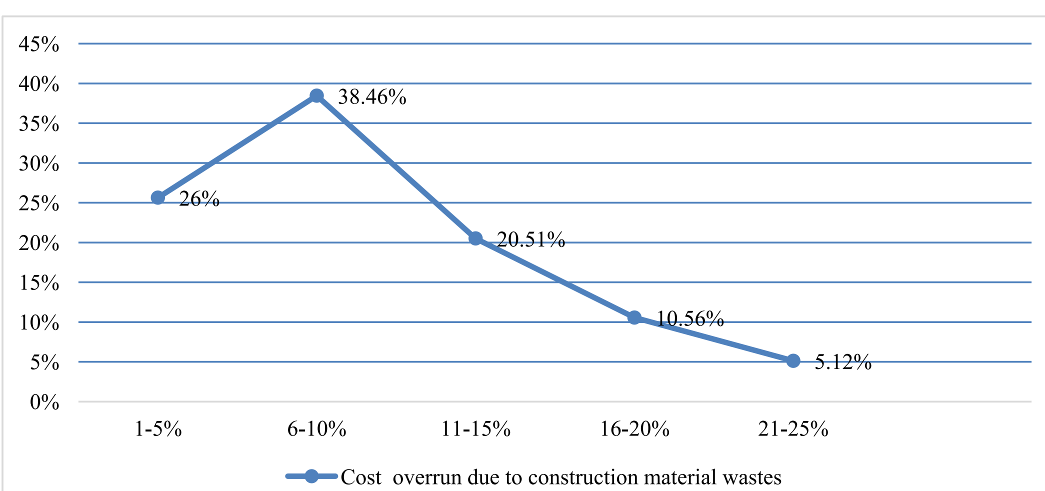


Figure 4. Cost overrun due to construction material waste.

Table 4. Descriptive statistics and normality test of the collected data.

S.No.	Impacts of construction waste	Mean	Std. Deviation	Rank	Cronbach's alpha if item deleted a**	Kolmogorov-Smirnov test		
						Statistic	df	Sig.
EC1	Project cost overrun	4.21	.931	1	.953	.272	70	.000
EN1	Pollution of the environment by discharging chemicals and other materials	4.14	.967	2	.953	.284	70	.000
EC2	Reduction in Profit and failure of construction firms	4.00	1.090	3	.956	.271	70	.000
EN2	Excessive consumption of raw material and resources depletion	3.99	1.210	4	.955	.256	70	.000
SE1	Public health and safety risks	3.97	1.179	5	.952	.238	70	.000
EN3	Pollution of soil by chemicals and other materials	3.93	1.121	6	.952	.240	70	.000
EC3	Delay of project time or time overrun	3.91	1.100	7	.952	.274	70	.000
EC4	Spending costs to landfill fee for disposing of waste	3.90	1.079	8	.952	.223	70	.000
EN4	Sustainability reduction of construction sectors	3.87	1.006	9	.956	.237	70	.000
EN5	Generate waste that causes water pollution	3.83	1.239	10	.952	.269	70	.000
EN6	Land occupancy or land consumption for dumping waste	3.81	.997	11	.956	.188	70	.000
SE2	Traffic congestion	3.79	1.034	12	.953	.194	70	.000
EC5	Transportation charges to transport waste	3.77	1.253	13	.953	.208	70	.000
EN7	Effect on biodiversity and destruction of the living environment	3.76	1.233	14	.952	.207	70	.000
EC6	Lower the GDP contribution of construction firms	3.74	1.359	15	.953	.275	70	.000
SE3	Disease-associated with high levels of air pollutants	3.73	1.350	16	.956	.251	70	.000
EN8	Severe effects on the welfare of the waste disposed communities	3.67	1.176	17	.954	.210	70	.000
EC7	Increase price of raw materials	3.66	1.361	18	.952	.257	70	.000
EN9	Emission of greenhouse gases into the atmosphere causes climate change	3.61	1.487	19	.954	.288	70	.000
EN10	*Increase in illegal dumping* ***b**** ***	*3.60*	*1.459*		.958	.231	70	.000
EN11	Dust generation to the surrounding	3.47	1.411	20	.954	.217	70	.000
SE4	Flooding due to blockages by waste debris	3.43	1.420	21	.953	.256	70	.000
SE5	Disagreement between construction parties	3.40	1.232	22	.953	.158	70	.000
SE6	Losing reputability and caused conflicts with the community	3.37	1.374	23	0.56	.176	70	.000
EC8	Reduce the crop productivity	3.21	1.371	24	.954	.181	70	.000

a**; Overall Cronbach's alpha coefficient is 0.956.
b***; Item was removed because it does not contribute to the overall reliability.
EC; economic impacts, SE; social impacts, and EN are environmental impacts of construction waste.

3.4.1. Economic impacts

As shown in Table 4, the overrun of construction project costs is the first economic impact ranked caused by construction waste (mean = 4.21). Ones if construction waste occurs on construction sites, there will be a need to replace and rework, transport, and dispose of waste materials that require extra costs. In this regard, waste has been noted as a negative economic impact by contributing additional costs (Eze et al., 2016; Mydin et al., 2014). For instance, the contribution of construction waste is 30% of the project cost overrun of materials (Olusanjo et al., 2014), depending on the material type, 8.47%–16.61% amount is recorded as wastage (Adewuyi and Odesola, 2016). In Nigeria, the percentage contribution of material waste to project cost overrun ranges from 1.96% to 8.01%, with an average contribution of 4.0%, as reported by (Saidu and Shakantu, 2016). Therefore, it has been noted that the increasing construction waste causes cost overrun or economic inefficiency of the projects (Li et al., 2013).

Table 4 also shows that a reduction in profit that causes the failure of construction firms is second in the economic impact of the increased generation of construction waste (mean = 4.00). The profit of construction companies depends on the proper use of material resources or resource efficiency, and if there are any types of material recorded as waste, there will be associated costs in addition to the purchasing costs of materials. Therefore, construction wase results in financial loss causing a reduction of the profit and failure of the construction sector (Wahab and Lawal, 2011; Dajadian and Koch, 2014). Nowadays, construction waste is a critical issue faced in many countries of construction projects. For example, Eze et al. (2016), demonstrated that construction waste is one of the leading causes of business failure among building stakeholders in developing countries.

In addition, delay of project time or time overrun is the third-ranked economic impact as a result of waste in construction sites (mean = 3.91). Construction waste causes the project to be delayed due to the fact that there is the time needed to clean or remove waste materials, replace and rework. In particular, the project schedule is one of the main aspects that is highly impacted by construction waste (Memon et al., 2020). Despite the fact that construction waste has a significant economic impact, losing reputability and causing conflicts with the community (mean = 3.37), is the least ranked economic impact of construction waste.

3.4.2. Social impacts

The community has suffered as a result of construction waste. From Table 4, it can be seen that public health and safety risks (mean = 3.97), traffic congestion (mean = 3.79), and disease-associated with high levels of air pollutants (mean = 3.73) are the three most influential impacts of construction waste respectively. Similar to the other waste impact categories, the two factors with the least significant economic impacts of waste include; flooding due to blockages by waste debris (mean = 3.43) and disagreement between construction parties (mean = 3.40), respectively. This study has indicated construction waste has a potential impact on the health and wellbeing of society as it is mostly disposed of near residences and significantly pollutes the environment.

Continuous and improper waste disposal contributes to air and water pollution, both of which are harmful to human health and have serious consequences for the welfare of the communities (Chooi et al., 2018; Samuel, 2019; Rodríguez et al., 2020). The study also pointed out health hazards, disasters, overflow incidences, and environmental pollution are just a few of the negative impacts of construction waste (Nguimalet, 2007). The negative impacts caused by construction waste include;

aesthetically unattractive surroundings, loss of land, increase in the spread of diseases, community health suffers in the vicinity of waste accumulation, and air and water pollution (Aboginije et al., 2020). In addition, waste from construction sites is dumped around the roadside creating traffic congestions and closing the drainage system that diverts the flow of floods to roads and houses of the community. Transportation and traffic congestion have been similarly indicated to be placed at the highest risk point influenced by construction waste from construction projects (ELARD and GAA, 2009).

3.4.3. Environmental impacts

As shown in Table 4, based on the result obtained from the compressive analysis, the first environmental impact ranked of construction waste is environmental pollution (mean = 4.14). Waste generated on construction sites pollutes the environment by releasing chemicals and other materials into it. Environmental pollution has also been reported as one of the most significant impacts of construction waste (Nayanthara and S.B.K.H, 2008; Coelho and Brito, 2012; Hossain and Ng, 2019). The construction industry generates a significant amount of waste that causes environmental pollution (Li et al., 2013; Ajayi et al., 2015; Anderson and Thornback, 2012), by contributing more than 33% of global CO_2 emissions (Baek et al., 2013).

In addition to that, excessive consumption of raw material consumption and depletion of natural resources (mean = 3.89) rank second in its adverse effect on the environment. The main sources of construction materials are nonrenewable and are increasingly degraded and depleted. The construction project becomes a major environmental burden, consuming bulk non-renewable resources and raw materials, along with generating great quantity waste (Faleschini et al., 2016; Husnain et al., 2017). Construction projects consumed approximately 40% of the natural resources and energy (Wu, 2003), and improper management waste resulted in the depletion of natural resources (Castellano et al., 2016).

The polluting of soil by chemicals and other materials created by construction waste is found to be the third environmental impact of construction waste (mean = 3.93) as perceived by the respondents. Construction waste is dumped inside or outside the site in direct contact with the soil. In Ethiopia, there are no policy implications, characterization, or methods of separating harmful waste and disposing of them. This is in line with the argument (Olusanjo et al., 2014), that waste consumes land and heavily contaminates the soil, having a significant impact on agricultural productivity and forestation. Furthermore, this result is in agreement with the findings of (Mbala et al., 2019), who ranked land pollution by construction waste as the most detrimental impact of construction waste. In another direction, the reduction of construction waste means reducing the amount of hazardous waste and, in turn, reducing the impact of waste on the environment (Liu et al., 2020).

3.5. Waste management strategies

The large proportions of waste generated from the construction industry have had adverse environmental and socioeconomic impacts, and therefore there is a need to promote construction waste management practices (Bakchan and Faust, 2019). Preventing and reducing waste streams helps to control its socio-economic and environmental impacts and achieve sustainability (Ajayi et al., 2015, 2017). However, effective control of construction waste would not be possible without the implementation of waste minimization or management strategies (Tafesse, 2021). If construction waste management strategies are effectively implemented, its potential economic, environmental, and social benefits are immense (Kofoworola and Gheewala, 2009), the implementation of waste reduction initiatives during construction work saves costs and reduces environmental impacts (Gottsche and Kelly, 2018). The environmental, economic, and social benefits of implementing waste management strategies are significant in improving the sustainable construction industry (Jaillon and Poon, 2008). The implementation of waste control strategies in Ethiopian construction companies was assessed using Yes/No questions, and the result is shown in Table 5.

As indicated in Table 4, 45.71% (32) of construction companies implemented waste management strategies capable of mitigating construction waste and its impacts. However, the majority of respondents (54.29%) stated that no specific waste control measures were in place at their organization. Participants who answered "yes" (45.71%) were asked to express their experience with waste management practices used in construction projects via an open-ended questionnaire and interviews. Table 6 summarises the results of content analysis on the responses.

Table 5. Implementation of waste management strategies.

Response	Frequency	Percentage (%)
Yes	32	45.71
No	38	54.29
Total	70	100

Table 6. Construction waste management practices.

No. Waste management practices
1. Employing a specific professionals to inspect and handle construction waste related issues
2. Adoption of prefabricated or off-site production of components and recent technology products which enable to reduce construction waste
3. Strong coordination between consultant, client, contractors, and other stakeholders during the planning, design, and construction stages of projects.
4. Implement strong onsite management practice and create awareness among the construction work members
5. Reusing and recycling the material leftover on sites
6. Offer incentives and tender premiums related to waste management
7. Increased implementation of green building codes and specifications
8. Introduction of penalties for construction firms with poor waste management practices
9. Increased landfill charges
10. Incorporation of a material waste minimization plan policy in construction contracts
11. Measuring the size of the work and using the proper amount of material on site help to reduce the work item needed to rework, repair and replace.
12. Enhancing proper material storage, effective and frequent site supervision
13. Taking into account the environment during designing and aiming to achieve resource optimization
14. Providing scheduled training on material waste minimization strategies for construction workers
15. Keep in mind the economic, social, and environmental effects of waste at all stages of the project

4. Conclusion

The objective of this paper was to identify the negative consequences of construction waste generated by construction projects. A literature review and expert interviews were used to identify the socioeconomic and environmental impacts of waste. A list of 25 negative waste impacts was compiled and quantitatively analyzed using descriptive statistics. Based on the results of the comprehensive analysis, it is possible to conclude that construction waste has become a major environmental and socioeconomic concern in Ethiopia, due to the increasing amount of waste generated by construction projects in nearly 95.71% of the ongoing construction projects. However, only 57.14% of the companies have recorded and measured the amount of construction waste generated from their sites. Due to construction material waste, the majority of construction companies experience a 6–10% cost overrun compared to the total cost of purchased materials. At the same time, the overall response of the participant was between 1-25%, with an average contribution of 12.5% of material cost overrun.

This study also contributed its findings, revealing that the top-ranked impacts of construction waste are; project cost overrun, pollution of the environment by discharging chemicals and other materials, reduction in profit and failure of construction firms, excessive consumption of raw materials leading to resource depletion, and public health and safety risks. To prevent the stream of waste and achieve sustainable construction projects; hiring a waste management officer, using prefabricated or off-site components, implementing strong onsite management practices, reusing and recycling material left on sites, increasing the implementation of green building codes and specifications, and instituting penalties for poor waste management practices are a devised measures that should be implemented by construction stakeholders. Therefore, the main contribution of this study is the critical impacts of construction waste and management practices in the Addis Ababa construction industry. The finding of the study allows which aspects must be addressed first to improve waste efficiency and sustainability on construction sites using the indicated management measures.

Declarations

Author contribution statement

Shitaw Tafesse: Conceived and designed the experiments; Analyzed and interpreted the data.

Yidnekachew Esayas Girma: Performed the experiments; Wrote the paper.

Eliyas Dessalegn: Performed the experiments; Contributed reagents, materials, analysis tools or data.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability statement

Data included in article/supplementary material/referenced in article.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

References

Aboginije, A., Aigbavboa, C., Thwala, W., 2020. Determining the impact of construction and demolition waste reduction practices on green building projects in Gauteng province, South Africa. In: Proceedings of the International Conference on Industrial Engineering and Operations Management. UAE, Dubai.

Adewuyi, T.O., Otali, M., 2013. Evaluation of causes of construction material waste: case of rivers state, Nigeria. Ethiopian Journal of Environmental Studies and Management 6, 746–753.

Adewuyi, T.O., Odesola, I.A., 2016. Material waste minimization strategies among construction firms in south-south Nnigeria. International Journal of Sustainable Construction Engineering & Technology 7 (1), 11–29.

Ajayi, S.O., et al., 2017. Optimising material procurement for construction waste minimization: an exploration of success factors. Sustainable Materials and Technologies 11, 38–46.

Ajayi, S.O., et al., 2015. Waste effectiveness of the construction industry: understanding the impediments and requisites for improvements. Resour. Conserv. Recycl. 102, 101–112.

Akadiri, P.O., Chinyio, E.A., Olomolaiye, P.O., 2012. Design of a sustainable building: a conceptual framework for implementing sustainability in the building sector. Buildings 2 (2), 126–152.

Al-Hajj, A., Hamani, K., 2011. Material waste in the UAE construction industry: main causes and minimization practices. Architect. Eng. Des. Manag. 7 (4), 221–235.

Anderson, J., Thornback, J., 2012. A Guide to Understanding the Embodied Impacts of Construction Products. Construction Products Association, London.

Asif, M., Muneer, T., Kelley, R., 2007. Life cycle assessment: a case study of a dwelling home in Scotland. Build. Environ. 42 (3), 1391–1394.

Aslam, M.S., Huang, B., Cui, L., 2020. Review of construction and demolition waste management in China and USA. J. Environ. Manag. 264 (110445).

Asmara, S., 2015. Managing and Minimizing Wastage of Construction Materials on Selected Public Building Projects in Addis Ababa. M.Sc. Thesis, Addis Ababa Institute of Technology, Addis Ababa, Ethiopia. http://etd.aau.edu.et/handle/123456789/5301.

Baek, C., Park, S., Suzuki, M., Lee, S., 2013. Life cycle carbon dioxide assessment tool for buildings in the schematic design phase. Energy Build. 61, 275–287.

Bajjou, M.S., Chafi, A., 2019. Exploring Causes of Wastes in the Moroccan Construction Industry. Springer Nature, Switzerland.

Bakchan, A., Faust, K.M., 2019. Construction waste generation estimates of institutional building projects: leveraging waste hauling tickets. Waste Manag. 87, 301–312.

Banias, G., et al., 2011. A web-based decision support system for the optimal management of construction and demolition waste. Waste Manag. 31, 2497–2502.

Castellano, J., Ribera, A., Ciurana, J., 2016. Integrated system approach to evaluate social, environmental and economics impacts of buildings for users of housings. Energy Build. 123, 106–118.

Chooi, M.M., Takeshi, F., Chin, S.H., 2018. Environmental impacts of construction and demolition waste management alternative. Chem. Eng. Trans. 63, 343–348.

Coelho, A., Brito, J.d., 2012. Influence of construction and demolition waste management on the environmental impact of buildings. Waste Manag. 32, 532–541.

Creswell, J.W., 2013. Qualitative Inquiry and Research Design: Choosing Among Five Approaches, third ed. Sage, Thousand Oaks.

Cronbach, L.J., 1951. Coefficient alpha and the internal structure of tests. Psychometrika 16 (3), 297–334.

da Paz, D.H.F., et al., 2018. Assessment of environmental impact risks arising from the illegal dumping of construction waste in Brazil. Environ. Dev. Sustain. 22, 2289–2304.

Dajadian, S.A., Koch, D.C., 2014. Waste management models and their applications on construction sites. Int. J. Construct. Eng. Manag. 3 (3), 91–98.

Edwards, B., 2014. Rough Guide to Sustainability: A Design Primer. RIBA Publishing, Lomdon.

ELARD, GAA, 2009. Environmental and Social Impact Assessment of Construction and Operation of Syria Cement Plant and Captive Power Plant, and Associated Quarrying Activities. Syrian cement company, Syria (scc).

Endale, T., 2017. Assessment of construction waste management and disposal strategies. MSc. Thesis. In: The Case of Gelan Condominium Construction Project Site. Addis Ababa Science and Technology University, Addis Ababa, Ethiopia.

Enshassi, A., Al-Hallaq, K., Mohamed, S., 2006. Causes of contractors' business failure in developing countries: the case of Palestine. J. Constr. Dev. Ctries. (JCDC) 11 (2), 1–14.

Enshassi, A., Kumaraswamy, M., Jomah, A.N., 2010. Significant factors causing time and cost overruns in construction projects in the Gaza strip: contractors' perspective. Int. J. Constr. Manag. 10, 35–60.

Eze, E.C., Seghosime, R., Eyong, O.P., Loya, O.S., 2016. Assessment of materials waste in the construction industry: a view of construction operatives, tradesmen and artisans in Nigeria. Int. J. Eng. Sci. 6 (4), 32–47.

Faleschini, F., Zanini, M.A., Pellegrino, C., Pasinato, S., 2016. Sustainable management and supply of natural and recycled aggregates in a medium-size integrated plant. Waste Manag. 49, 146–155.

Fashina, A.A., Fakunle, F.F., Omar, M.A., 2020. A Study on the effects of construction project delays in Somaliland construction industry. J. Manag. Econ. Ind. Organ. (3), 89–102.

Fashina, A.A., Omar, M.A., Sheikh, A.A., Fakunle, F.F., 2021. Exploring the significant factors that influence delays in construction projects in Hargeisa. Heliyon 7 (4).

Feild, A., 2013. Discovering Statistics Using IBM SPSS Statistics. SAGE, London.

Ghaleb, J.S., et al., 2021. Understanding the causes of material wastage in the construction industry. Jordan J. Civil Eng. 5 (2), 180–192.

Gottsche, J., Kelly, M., 2018. Assessing the impact of construction waste reduction on selected projects in Ireland. Waste Res. Manag. 171 (3), 71–81.

Hakan, A., Nilay, C., Burcu, S., 2012. Construction and Demolition Waste Management in Turkey. Waste Management, pp. 314–332.

Hossain, M.U., Ng, S.T., 2019. Influence of waste materials on buildings' life cycle environmental impacts: adopting resource recovery principle. Resour. Conserv. Recycl. 142, 10–23.

Husnain, A., Muhammad, Q., Muhammad, J.T., Hamza, F.G., 2017. Quantification of material wastage in construction industry of Pakistan: an analytical relationship between building types and waste generation. J. Constr. Dev. Ctries. (JCDC) 22 (2), 19–34.

Ignacio, Z.B., Antonio, V.C., Alfonso, A.U., 2011. Life cycle assessment of building materials: comparative analysis of energy and environmental impacts and evaluation of the eco-efficiency improvement potential. Build. Environ. 46 (5), 1133–1140.

Jaillon, L., Poon, C.S., 2008. Sustainable construction aspects of using prefabrication in dense urban environment: a Hong Kong case study. Construct. Manag. Econ. 26 (9), 953–966.

Jawad, Al-R., Omar, A., 2016. Understanding the key factors of construction waste in Jordan. Jordan J. Civil Eng. 10 (2), 244–253.

Jekale, W., 2004. Performance for Public Construction Projects in Developing Countries: Federal Road and Educational Building Projects in Ethiopia. Norwegian University of Science and Technology.
Josimovic, B., Maric, I., Milijic, S., 2014. Multi-criteria Evaluation in Strategic Environmental Assessment for Waste Management Plan, a Case Study: the City of Belgrade. Waste Manag.
Kabirifar, K., Mojtahedi, M., Wang, C.C., 2021. A systematic review of construction and demolition waste management in Australia: current practices and challenges. Recycling 6 (2), 34.
Kofoworola, O.F., Gheewala, S.H., 2009. Estimation of construction waste generation and management in Thailand. Waste Manag. 29, 731–738.
Laborel-Préneron, A., et al., 2016. Plant aggregates and fibers in earth construction materials: a review. Construct. Build. Mater. 111, 719–734.
Li, J., Ding, Z., Mi, X., Wang, J., 2013. A model for estimating construction waste generation index for building project in China. Resour. Conserv. Recycl. 74, 20–26.
Liu, J., Yi, Y., Wang, X., 2020. Exploring factors influencing construction waste reduction: a structural equation modeling approach. J. Clean. Prod. 276, 123185.
Lopes, J.P., Oliveira, R.A., Amreu, M.I., 2011. The Construction Industry and the Challenges of the Millennium Development Goals. Management and Innovation for a Sustainable Built Environment. Amsterdam, The Netherlands. http://resolver.tudelft.nl/uuid:8c0f430b-045a-428a-a188-84575441c605.
Lu, W., Yuan, H.P., 2011. A framework of understanding waste management studies in construction. Waste Manag. 31 (6), 1252–1260.
Luangcharoenrat, C., Intrachooto, S., Peansupap, V., Sutthinarakorn, W., 2019. Factors influencing construction waste generation in building construction: Thailand's perspective. Sustainability 11 (13), 3638.
Mbala, M., Aigbavboa, C., Aliu, J., 2019. Reviewing the negative impacts of building construction activities on the environment: the case of Congo. published in. In: Advances in Human Factors,sustainable Urban Planning and Infrastructur. Springer International Publishing.
Memon, M.A., et al., 2020. Identification of causes for construction waste material in construction projects of Sindh province. Int. Res. J. Innov. Eng. Technol. (IRJIET) 4 (10), 7–13.
Merino, M.d.R., Gracia, P.I., Azevedo, I.S.W., 2010. Sustainable construction: construction and demolition waste reconsidered. Waste Manag. Res. 28 (2), 118–129.
Milad, Z., Sungjin, K., 2020. Dynamic Modeling for life cycle cost analysis of BIM-based construction waste management. Sustainability 12 (6), 2483.
Muhammad, F.H., et al., 2020. The on-site waste minimization practices for construction waste. IOP Conference Series: materials Science and Engineering. IOP Conf. Ser. Mater. Sci. Eng. 713, 012038.
Musarat, A.M., Alaloul, W.S., Liew, M.S., Maqsoom, A., 2020. Qureshi, A. H. Investigating the impact of inflation on building materials prices in construction industry. J. Build. Eng. 32.
Mydin, M.O., Khor, J.C., Sani, N.M., 2014. Approaches to construction waste management in Malaysia. Advanced green material and Technology symposium (AGMTS 2014). MATEC Web Conf. 17, 1014.
Narcis, N., Ray, I., Hosein, G., 2019. Construction and demolition waste management actions and potential benefits: a perspective from Trinidad and Tobago. Buildings 9 (6), 150.
Nayanthara, D.S., S B K H, V., 2008. Use of PC elements for waste minimization in the Sri Lankan construction industry. Struct. Surv. 26 (3), 188–198.
Nguimalet, C.R., 2007. Population and Spatial Growth: Diagnosis and Implications for Urban Management in Bangui (Central African Republic), pp. 1–16.
Nunnally, J.C., Bemstein, I.H., 2007. PsychometricTheory. McGraw-Hill, New York.
Ofori, G., 2015. Nature of the construction industry, its needs and its development: a review of four decades of research. J. Constr. Dev. Ctries. (JCDC) 20 (2), 115–135.
Oladipo, F.O., Oni, O.J., 2012. A review of selected macroeconomic factors impacting building material prices in developing countries- a case of Nigeria. Ethiop. J. Environ. Stud. Manag. EJESM 5 (2), 131–137.
Olanrewaju, S.D., Ogunmakinde, O.E., 2020. Waste minimisation strategies at the design phase: architects' response. Waste Manag. 118, 323–330.
Olusanjo, O.F., Panos, G., Ezekiel, C., 2014. Quantitative analysis of the sources of construction waste. J. Constr. Eng. 2014 (651060), 9.
Papargyropoulou, E., Preece, C., Padfield, R., Abdullah, A.A., 2011. Sustainable construction waste management in Malaysia: a contractor's perspective. In: Proc. Of the Int. Conf. on Manag. Innov. a Sustain. Built Environ. Delft University of Technology, Amsterdam, Holland.
Pheng, L.S., Hou, L.S., 2019. The Economy and the Construction Industry. Construction Quality and the Economy, pp. 21–54.
Polat, G., Damci, A., Turkoglu, H., Gurgun, A.P., 2017. Identification of root causes of construction and demolition (C&D) waste: the case of Turkey. Procedia Eng. 196, 948–955.
Rodríguez, G., et al., 2020. Construction and demolition waste applications and maximum daily output in Spanish recycling plants. Waste Manag. Res. 38 (4), 423–432.
Saidu, I., Shakantu, W., 2016. The contributions of construction material waste to project cost overruns in Abuja, Nigeria. Acta Structilia 23 (1), 99–113.
Samuel, M.P., 2019. Environmental and socio-economic effect of solid waste on local livelihood in Sierra Leone: a case study of freetown municipality. Int. J. Res. Bus. Stud. Manag. 6 (7), 14–22.
Shant, A.D., Daphene, C.K., 2014. Waste management models and their applications on construction sites. Int. J. Construct. Eng. Manag. 3 (3), 91–98.
Solís-Guzmán, J., Marrero, M., Montes-Delgado, M., Ramírez-de-Arellano, A., 2009. A Spanish model for quantification and management of construction waste. Waste Manag. 29 (9), 2542–2548.
Tafesse, S., 2020. A review on the critical factors causing delay of delivery time in construction projects. Int. J. Eng. Technol. IJET 6 (4), 69–81.
Tafesse, S., Adugna, T., 2021. Critical factors causing material wastes in building construction projects. J. Eng. Sci. 17 (2), 1–16.
Tafesse, S., 2021. Material waste minimization techniques in building construction projects. Ethiop. J. Sci. Technol. 14 (1), 1–19.
Tam, W.Y., 2008. On the effectiveness in implementing a waste-management-plan method in construction. Waste Manag. 28 (6), 1072–1080.
Venugopal, R.B., Sundeep, K.N., Venkatesh, K., 2020. A study on factors involved in implementation of supply chain management in construction industry. Mater. Today Proc. 33 (1), 446–449.
Wahab, A.B., Lawal, A.F., 2011. An evaluation of waste control measures in construction industry in Nigeria. Afr. J. Environ. Sci. Technol. 5 (3), 246–254.
Wong, E.O., Yip, R.C., 2004. Promoting sustainable construction waste management in Hong Kong. Construct. Manag. Econ. 22 (6), 563–566.
Wu, Y.W., 2003. The foreground of green-building development [Online] Available at: www.zhb.gov.cn. (Accessed 10 June 2021).
Wu, Z., Yu, A.T., Shen, L., 2016. Investigating the determinants of contractor's construction and demolition waste management behavior in Mainland China. Waste Manag. 60, 290–300.
Ye, G., Jin, Z., Xia, B., Skitmore, M., 2014. Analyzing causes for reworks in construction projects in China. J. Manag. Eng. 31, 1–9.
Yeheyis, M., et al., 2013. An overview of construction and demolition waste management in Canada: a lifecycle analysis approach to sustainability. Clean Technol. Environ. Policy 15, 81–91.
Yuan, H., Chini, A.R., Lu, Y., Shen, L., 2012. A dynamic model for assessing the effects of management strategies on the reduction of construction and demolition waste. Waste Manag. 32, 521–531.